CLAIMS

1. Fluid colloidal crystals comprising a solid-liquid colloidal dispersion containing monodisperse spherical colloidal particles as a dispersoid, wherein:

the spherical colloidal particles are organic or inorganic polymer monodisperse dispersoid spherical colloidal particles having a mean volume diameter (d) of not more than 30 μm,

the solid-liquid colloidal dispersion comprises the dispersoid having a dispersion concentration, as expressed on the volume basis, of not less than 20% and not more than 70% and an aqueous solution or a dissolving water-containing non-aqueous solution as a dispersion medium,

around the dispersoid spherical colloidal particles in the solid-liquid colloidal dispersion having an electrostatic charging degree of not more than 2000 μS/cm in terms of an electrical conductivity, an electric double layer of a given thickness (Δe) is formed at a temperature of not lower than a freezing point of the dispersion medium solution, and

the dispersoid spherical colloidal particles form a three-dimensionally ordered lattice that shows fluidity and is a particle array structure in which the spherical

colloidal particles are longitudinally and laterally aligned in a lattice form while an interparticle distance (L) defined as a distance between centers of the particles arranged opposite to each other along the center line satisfies the relationship (d) < (L) ≤ (d)+2(Δe).

2. The fluid colloidal crystals as claimed in claim 1, wherein the dispersoid spherical colloidal particles are organic or inorganic polymer monodisperse specific spherical colloidal particles having one black color type achromatic color selected from grayish white, gray, grayish black and black and having a mean volume diameter (d) of 130 to 350 nm, and the three-dimensionally ordered lattice comprising these particles develops a clear chromatic spectral diffraction color under irradiation with natural light or white light.

3. The fluid colloidal crystals as claimed in claim 2, wherein the chromatic spectral diffraction color visually sensed, which is a vertical color appearance on the surface of the three-dimensionally ordered lattice, and the interparticle distance (L) satisfy any one of the following relationships (I) to (V):

(I) when (L) is in the range of 160 to 170 nm, the chromatic color developed is clear purple (P),

(II) when (L) is in the range of 180 to 195 nm, the chromatic color developed is clear blue (B),

(III) when (L) is in the range of 200 to 230 nm, the chromatic color developed is clear green (G),

(IV) when (L) is in the range of 240 to 260 nm, the chromatic color developed is clear yellow (Y), and

(V) when (L) is in the range of 270 to 290 nm, the chromatic color developed is clear red (R).

4. The fluid colloidal crystals as claimed in claim 1, wherein the dispersoid colloidal particles are organic or inorganic polymer monodisperse specific spherical colloidal particles having a mean volume diameter (d) of 10 to 130 nm, and the three-dimensionally ordered lattice comprising these particles exhibits ultraviolet ray reflection properties under irradiation with ultraviolet rays having a wavelength of not more than 400 nm.

5. The fluid colloidal crystals as claimed in claim 1, wherein the dispersoid colloidal particles are organic or inorganic polymer monodisperse specific

spherical colloidal particles having a mean volume diameter (d) of 350 to 800 nm, and the three-dimensionally ordered lattice comprising these particles exhibits infrared ray reflection properties under irradiation with infrared rays having a wavelength of 800 to 1500 nm.

6. The fluid colloidal crystals as claimed in any one of claims 1 to 5, wherein the dispersoid colloidal particles are organic polymer spherical particles of at least one polymer selected from (meth)acrylic polymers, (meth)acrylic-styrene polymers, fluorine substituted (meth)acrylic polymers and fluorine substituted (meth)acrylic-styrene polymers.

7. A process for producing a three-dimensionally ordered lattice of spherical fine particles, comprising:

preparing fluid colloidal crystals (S-1) comprising, as a dispersoid, organic or inorganic polymer monodisperse spherical colloidal particles having a mean volume diameter (d) of not more than 30 μm, and as a dispersion medium, an aqueous solution or a dissolving water-containing non-aqueous solution, wherein the dispersion concentration of the colloidal particles, as

expressed on the volume basis, is not less than 20% and not more than 70%, around the dispersoid spherical colloidal particles in the solid-liquid colloidal dispersion having an electrostatic charging degree of not more than 2000 μS/cm in terms of an electrical conductivity, an electric double layer of a given thickness (Δe) is formed at a temperature of not lower than a freezing point of the dispersion medium solution, and the dispersoid spherical colloidal particles form a three-dimensionally ordered lattice that shows fluidity and is a particle array structure in which the spherical colloidal particles are longitudinally and laterally aligned in a lattice form while an interparticle distance (L) defined as a distance between centers of the particles arranged opposite to each other along the center line satisfies the relationship $(d) < (L) \leq (d)+2(\Delta e)$,

then forming a green sheet of the suspension of the above (S-1) and exposing the green sheet to an atmosphere having a temperature exceeding the freezing point of the dispersion medium to dry it and thereby form a three-dimensionally ordered lattice of the spherical fine particles regularly aligned longitudinally and laterally, and

subsequently applying or spraying any one of a polymerizable organic monomer solution, an organic polymer solution and an inorganic binder solution so as to fill a surface of the three-dimensionally ordered lattice and gaps among the three-dimensionally aligned particles, followed by polymerization or curing.

8. A process for producing a three-dimensionally ordered lattice of spherical fine particles, comprising:

preparing fluid colloidal crystals (S-2) comprising, as a dispersoid, organic or inorganic polymer monodisperse spherical fine particles having one black color type achromatic color selected from grayish white, gray, grayish black and black and having a mean volume diameter (d) of 130 to 350 nm, and as a dispersion medium, an aqueous solution or a dissolving water-containing non-aqueous solution, wherein the dispersion concentration of the dispersoid, as expressed on the volume basis, is not less than 20% and not more than 70%, and the electrical conductivity of the solid-liquid dispersion is not more than 2000 μS/cm,

then forming a green sheet of the suspension of the above (S-2) and exposing the green sheet to an atmosphere having a temperature exceeding a freezing point of the

dispersion medium to dry it and thereby form a three-dimensionally ordered lattice of the spherical fine particles regularly aligned longitudinally and laterally, and

subsequently applying or spraying any one of a polymerizable organic monomer solution, an organic polymer solution and an inorganic binder solution, a refractive index (nB) of a polymer or a cured product obtained from said solution being different from a refractive index (nP) of the spherical fine particles, so as to fill a surface of the three-dimensionally ordered lattice and gaps among the three-dimensionally aligned particles, followed by polymerization or curing.

9. A process for producing a three-dimensionally ordered lattice of spherical fine particles, comprising:

preparing fluid colloidal crystals (S-3) comprising, as a dispersoid, organic or inorganic polymer monodisperse spherical fine particles having a mean volume diameter (d) of 10 to 130 nm, and as a dispersion medium, an aqueous solution or a dissolving water-containing non-aqueous solution, wherein the dispersion concentration of the dispersoid, as expressed on the volume basis, is not less than 20% and not more than 70%,

and the electrical conductivity of the solid-liquid dispersion is not more than 2000 μS/cm,

then forming a green sheet of the suspension of the above (S-3) and exposing the green sheet to an atmosphere having a temperature exceeding a freezing point of the dispersion medium to dry it and thereby form a three-dimensionally ordered lattice of the spherical fine particles regularly aligned longitudinally and laterally, and

subsequently applying or spraying any one of a polymerizable organic monomer solution, an organic polymer solution and an inorganic binder solution, a refractive index (nB) of a polymer or a cured product obtained from said solution being different from a refractive index (nP) of the spherical fine particles, so as to fill a surface of the three-dimensionally ordered lattice and gaps among the three-dimensionally aligned particles, followed by polymerization or curing.

10. A process for producing a three-dimensionally ordered lattice of spherical fine particles, comprising:

preparing fluid colloidal crystals (S-4) comprising, as a dispersoid, organic or inorganic polymer monodisperse spherical fine particles having a mean

volume diameter (d) of 350 to 800 nm, and as a dispersion medium, an aqueous solution or a dissolving water-containing non-aqueous solution, wherein the dispersion concentration of the dispersoid, as expressed on the volume basis, is not less than 20% and not more than 70%, and the electrical conductivity of the solid-liquid dispersion is not more than 2000 μS/cm,

then forming a green sheet of the suspension of the above (S-4) and exposing the green sheet to an atmosphere having a temperature exceeding a freezing point of the dispersion medium to dry it and thereby form a three-dimensionally ordered lattice of the spherical fine particles regularly aligned longitudinally and laterally, and

subsequently applying or spraying any one of a polymerizable organic monomer solution, an organic polymer solution and an inorganic binder solution, a refractive index (nB) of a polymer or a cured product obtained from said solution being different from a refractive index (nP) of the spherical fine particles, so as to fill a surface of the three-dimensionally ordered lattice and gaps among the three-dimensionally aligned particles, followed by polymerization or curing.

11. The process for producing a three-dimensionally ordered lattice of spherical fine particles as claimed in any one of claims 7 to 10, wherein the binder is a transparent binder satisfying the relationship $|nP-nB| \geq 0.05$.

12. The process for producing a three-dimensionally ordered lattice of spherical fine particles as claimed in any one of claims 7 to 11, wherein the green sheet is formed on a supporting member which is a mesh material made of stainless steel, a fluororesin or nylon and having deep-ditch divisions having an opening of 1 to 10 mm and an aspect ratio of 0.4 to 0.8.

13. The process for producing a three-dimensionally ordered lattice of spherical fine particles as claimed in any one of claims 7 to 12, wherein the monodisperse spherical fine particles are organic polymer spherical particles of at least one polymer selected from (meth)acrylic polymers, (meth)acrylic-styrene polymers, fluorine substituted (meth)acrylic polymers and fluorine substituted (meth)acrylic-styrene polymers.

14. A process for producing a coating film of a three-dimensionally ordered lattice of spherical fine particles, comprising:

preparing fluid colloidal crystals (S-5) comprising, as a dispersoid, organic or inorganic polymer monodisperse spherical fine particles having a mean volume diameter (d) of 0.01 to 30 μm, and as a dispersion medium, an aqueous solution or a dissolving water-containing non-aqueous solution, wherein the dispersion concentration of the dispersoid, as expressed on the volume basis, is not less than 20% and not more than 70%, and the electrical conductivity of the solid-liquid dispersion is not more than 2000 μS/cm,

applying the fluid colloidal crystals (S-5) onto a plate selected from a glass plate, a plastic plate, a steel plate, an aluminum plate, a stainless steel plate, a ceramic plate, a wood plate and a fabric sheet,

then exposing the coated plate to an atmosphere having a temperature exceeding a freezing point of the dispersion medium to dry it and thereby form a three-dimensionally ordered lattice of the spherical fine particles regularly aligned longitudinally and laterally on the plate, and

subsequently applying or spraying any one of a polymerizable organic monomer solution, an organic polymer solution and an inorganic binder solution so as to fill a surface of the three-dimensionally ordered lattice and gaps among the three-dimensionally aligned particles, followed by polymerization or curing to fix the three-dimensionally ordered lattice of spherical fine particles as a coating film.

ABSTRACT

Disclosed are fluid colloidal crystals comprising a solid-liquid dispersion electrostatically charged at not more than 2000 μS/cm in terms of an electrical conductivity, wherein the solid-liquid dispersion comprises, as a dispersoid, electrostatically chargeable spherical colloidal particles of an organic or inorganic polymer having a mean volume diameter (d) of not more than 30 μm, and as a dispersion medium, an aqueous solution or a dissolving water-containing non-aqueous solution, the dispersion concentration of the spherical colloidal particles is not more than 70%, around the dispersoid an electric double layer of a given thickness (Δe) is formed, and the spherical colloidal particles form a three-dimensionally ordered lattice that shows fluidity and is a particle array structure in which the colloidal particles are aligned longitudinally and laterally in a lattice form while an interparticle distance (L) defined as a distance between centers of the particles arranged opposite to each other along the center line satisfies the relationship $(d) < (L) \leq (d)+2(\Delta e)$. Also disclosed is a process for producing a three-dimensionally ordered lattice, comprising drying the fluid colloidal crystals to form a three-

dimensionally ordered lattice which is a homogeneous particle array structure constituted of the organic or inorganic monodisperse spherical fine particles of the dispersoid.